EMBRYOLOGY.[1]

On the Significance of Spermatogenesis.[2]—Auerbach has recently shown that a characteristic of the ovum and of the sperm is the fact, that the nucleus of the former takes on a red color, while that of the latter takes a blue, when both are treated exactly in the same way; to use Auerbach's expression, the hereditary substance of the male is *cyanophilous*, while that of the female is *erythrophilous*. I have tried this method of differentiating the sexual cells in the following animals: Asterias, Loligo, Unio, Limax, Rana, Bufo, Necturus, Diemyctylus, Mouse, Rabbit, Dog, Cat, Tortoise, Fowl, and Man. I used three kinds of aniline colors, viz., Cyanine, for the blue staining, and Erothrosine and Chromotrop for the red. These anilines do not appear in the list of colors used by Auerbach, but they give the characteristic stains for the sperm and the ovum as described by him.

In all of the animals mentioned, the nuclear contents of the well developed spermatozoon is eminently cyanophilous, that is, it takes cyanine in preference to chromotrop or erythrosine, and the nuclear contents of the ovarian ovum, particularly the nucleolus, is erythrophilous, that is, it takes either erythrosine or chromotrop in preference to cyanine.

It is difficult, however, to tell how much of the contents of the nucleus of the ovarian ovum, before a portion of its chromosome has been removed in the formation of polar globules, is directly comparable with the nuclear contents of a single spermatozoon, and we are therefore in doubt as to how far a color contrast obtained in differential staining of the two sexual cells actually indicates the real nature of the chromosomes contributed by two parents to the body of an embryo. It seems important to bear this point in mind, for, in instituting comparisons between the nucleus of the spermatozoon and of the ovarian ovum, as representative elements of the maternal and the paternal organisms, one is left to infer that the protoplasmic contents of the two are in an analogous stage of development—an inference open to objection. If the germinal vesicle of the well-developed ovarian ovum is to be compared with any structure in the male organism, it ought to be compared with the nucleus of the sperm mother cell or the spermatocyte, and not with that of the spermatozoon.

[1]This department is edited by Dr. E. A. Andrews, Johns Hopkins University.

[2]An abstract of a paper read before the Biological Club, Clark University, Worcester, Mass., March 10, 1892.

As I have already indicated in my previous note on the *Sertoli's cell*,[1] the cyanophilous quality of the spermatozoon nucleus is only the final phase of the varied series of color-reactions, which the sperm-producing cell presents at different stages of its development. The male germinal substance is not always blue in its color reaction. The male germinal substance at the beginning (spermatogonium stage), is not cyanophilous, but its color reaction is violet, due probably to a mixture of blue and red color; while at the next stage (spermatocyte), the color reaction of the chromosome is decidedly *green*, with one or two intensely erythrophilous nucleoli.

The transition of the chromatophilous qualities of the nuclear substance of the male cell from *violet* (spermatogonium), *green* (spermatocyte), *greenish-blue* (spermatide) and *deep blue* (spermatozoon), each new color-reaction corresponding to the morphological change in the sperm-cell, is certainly very instructive as clearly shown in my preparations illustrating mammalian spermatogenesis. The change in the chromatophilous quality of the male cell at different stages of its existence, may be due to corresponding changes in the quality of the protoplasm itself, and the whole phenomena of the successive series of forms of the sperm-cell must be due to the corresponding alteration in the nature of the protoplasmic material: when the male cell assumes its final stage as a well-developed spermatozoon, with its complicated apparatus for locomotion, accompanied, as in many cases, with an accessory apparatus, which facilitates the penetration of the sperm-nucleus into the substance of the ovum (as the head-spine for boring and the recurved hook at its tip, etc.), the quality of the protoplasmic substance has changed so much as to take an entirely different color from that of the ovum, which maintains the typical characteristics of an animal cell. That the ovum and the sperm become differently colored is, then, just what we might expect on *a priori* grounds, knowing the analogous differences mentioned in the history of the spermatozoon alone.

The critical point one is most interested to know is, whether the blue color, which characterized the nucleus of the spermatozoon, still persists or not, after the sperm-cell has entered into the substance of the ovum, and the form of its nucleus has undergone change by becoming spherical again. According to Auerbach's theory of heredity, the blue color must persist. I am not able to say anything definitely on this point, for I have not yet finished my research on this particular subject. I have said enough, however, to show, that the

[1]This Journal for May, 1892, p. 442.

cyanophilous quality of the paternal nucleus is by no means a constant character. It does not appear improbable that, after the sperm-nucleus had become transformed into the male pronucleus, indistinguishable from the female pronucleus in its contour, in its size, in the arrangement and the number of its chromosomes—the points strongly emphasized already by many workers in this field—the quality of the "male" and the "female" substance may no longer be more distinguishable in color reactions than they are in other respects; and that such differences as exist between them may be simply those that differentiate one organism from another of the same species.

We may say then, that the differentiations of the germ cells in the two sexes, which are shown not only in their form and size, but also in their chemical qualities, indicated by differential staining, are the device indicated (to use figurative language) to secure the union of two different individuals, with a special view to effect the transit of the male cell to the ovum and that with the successful union, or the close approximation, of two germ pronuclei, the "sexes" of the pronuclei become lost and they become non-sexual.

Just what determines the sex of the resulting embryo, which starts from this non-sexual stage, is quite another question.

Since, in general, it is the male that deviates most from the original or non-sexual form, the formation of the sperm-cell by a process much more complicated than that of the ovum may find a parallel among the similar facts in the evolution of the so-called "secondary sexual characters." The "primary" sexual structure—the germ-cell—may be said to undergo a series of changes parallel to those that take place in somatic structures. The significance of the complicated process of spermatogenesis when compared with oogenesis lies in the fact that it is part of a general law.

But if the "primary sexual character," a structure taking a direct part in reproduction, pursues in its development a path similar to that of the development of a "secondary sexual character," or structure taking only an indirect part in reproduction, it follows that the distinction between "primary" and "secondary" sexual character is more or less a nominal one.—S. WATASE, Clark University, Worcester, Mass.

Non-Sexual Reproduction in Sponges.[1]—Prof. H. V. Wilson of Chapel Hill, N. C., makes an interesting contribution to the subject of sexual and non-sexual reproduction of animals in a paper upon the

development of certain undescribed silicious sponges, found upon the Massachusetts Coast and in the Bahama Islands.

Though the egg development was studied in a number of sponges it is only the non-sexual development by gemmules that is of special interest in this connection.

In *Esperella fibrexilis* n. sp. of Woods Holl, Mass., the first appearance of the gemmules was traced to certain plump cells in the mesoderm. Such cells collect into groups of varying size: in each group the central ones are rather closely packed while the outer ones arrange themselves in the form of a follicle. Such clusters are the gemmules. Though it is possible that some gemmules may be formed from single cells, most are aggregates of many separate cells and in all growth takes place not only by cell division inside the gemmule, but by the actual fusion of large and small gemmules; so that the ultimate mass is of complex multicellular origin.

When the gemmule is full grown it forms a spherical mass of closely packed cells with faintly marked boundaries and full of yolk. The entire mass now projects into a water-canal, suspended as it were by the stalk-like attachments of the follicle.

In this ripe gemmule a remarkable process of subdivision now takes place. The solid aggregate of cells breaks down into clusters of cells, which are separated by liquid. The division continues until all the cells of the gemmule became separated from one another. Then the outer ones rearrange themselves to form an outer layer covering a central mass of amœboid cells, all connected together by processes, though separated by liquid.

The outer layer becomes ciliated and rich in orange colored pigment. At one pole, however, this change does not take place and at the same pole the inner cells crowd together to form a dense mass in which spicules appear.

In this condition the larva breaks out of its follicle, leaves the sponge and swims about actively in the water.

The gemmule larva thus closely resembles an egg larva in having an outer layer of pigmented, ciliated cells (ectoblast) replaced at the *anterior* pole by a thin layer of cells not pigmented nor ciliated ; while the mesenchymatous central mass is dense and has spicules only at this same anterior end.

The larva attaches itself by its anterior end, but obliquely, so as to lie upon its side. Even before this a change extended from the anterior pole over the rest of the larva, the ectoderm becomes gradually

[1]Journal of Morphology, V, 1891.

flat and single. The sponge grows out as a circular disk, later becoming irregular. It is covered by the flat ectodermal membrane and inside contains spicules all through the mesenchymatous substance of the body.

The various canals and cavities of the sponge arise here and there with no arrangement. Later they connect with one another and break through to the surface as oscula and pores. The ciliated chambers are formed in the midst of special clusters of bulky mesoderm cells that divide to make walls about the intercellular space thus bounded. The way in which these special cells form the ciliated chambers varies in different larvæ.

In discussing the remarkable gemmule development the author points out that, if it has any value as indicating the past history of sponges, it is evidence of the former existence of a solid ancestor as maintained by Metschnikoff. It is mainly, however, the resemblance of this non-sexual larva to the egg larva of other sponges that is to be emphasized. Pointing out the resemblance in the formation of "germ layers" and the peculiarites of the anterior pole and changes of the "ectoderm," Dr. Wilson then accentuates the comparison by applying certain views of Prof. Weismann. As any mesenchyme cell may, apparently, produce an ovum so any mesenchyme cell may unite with others to make a gemmule. The gemmule cell has, alone, but little histogenetic plasma, but an aggregate can form a larva. The gemmule cell is thus a germ-cell differing from the ovum in having its germ plasma not partly converted into ovogenetic plasma. Some such likeness between the egg cell and the gemmule cell is necessary to explain the observed resemblances between the egg larva and the gemmule larva.

ARCHAEOLOGY AND ETHNOLOGY.[1]

MAN AND THE MYLODON.

Their Possible Contemporaneous Existence in the Mississippi Valley.

In one of the alcoves of the Museum of the Academy of Natural Sciences, Philadelphia is to be seen a considerable number of fossil bones of extinct animals belonging to the pleistocene period. In color, texture and general outward appearance they have a remarkable sim-

[1]This department is edited by Dr. Thomas Wilson, of the Smithsonian Institution.